# Cutting More than Metal: How New Technology and Flexible Engineering Can Enable Affordable Space Missions

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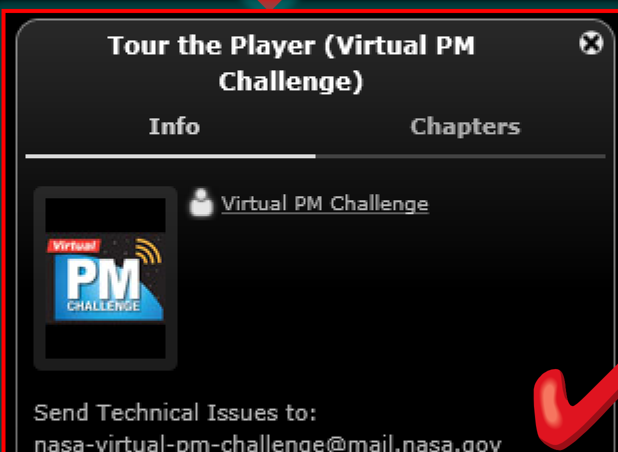
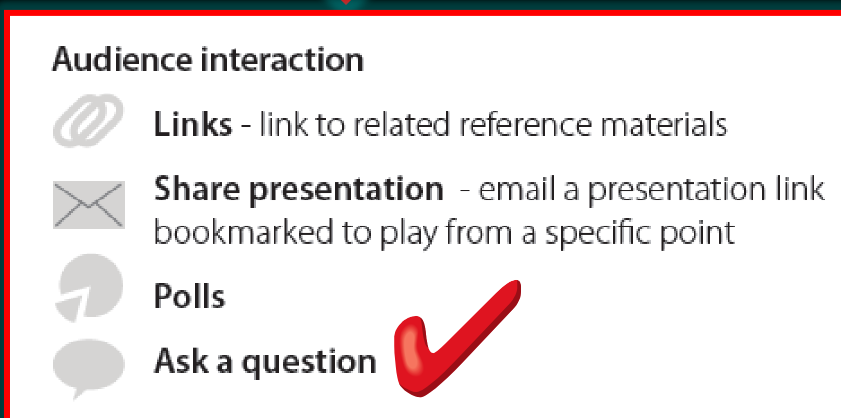
New technology is changing the way we do business at NASA. Enabled by a culture embracing innovation and flexibility that has a higher tolerance to risk, technology is impacting the entire product life cycle, from design and analysis, through production, verification, logistics and operations. New fabrication techniques such as additive manufacturing, verification techniques, integrated analysis, and models that follow the hardware from initial concept through operation are having an impact on the time and cost of building space hardware. Evolved Systems Engineering processes and policy at NASA are inherently more flexible than they have been in the past, enabling the implementation of new techniques and approaches.

# Ask Questions, Find Help

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**Erin Betts, NASA MSFC, ER21**
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**Manager, Systems Engineering Management Office**

marshall

# Agenda

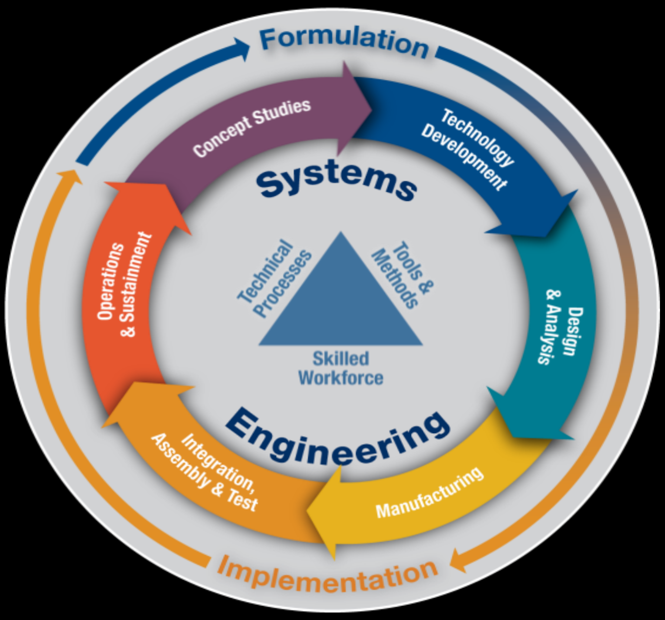
- Evolving technology in the areas of design, analysis, production, verification, logistics, and operations
  - Evolution of technology
  - New technology is changing the design process
  - Specific examples: Additive Manufacturing, Structured Light Scanning
- Program/Project lifecycle – Evolving the Program Management and Systems Engineering processes
  - Change in culture, communications, and product focus
  - Enable flexibility to accommodate new techniques and approaches, improving affordability

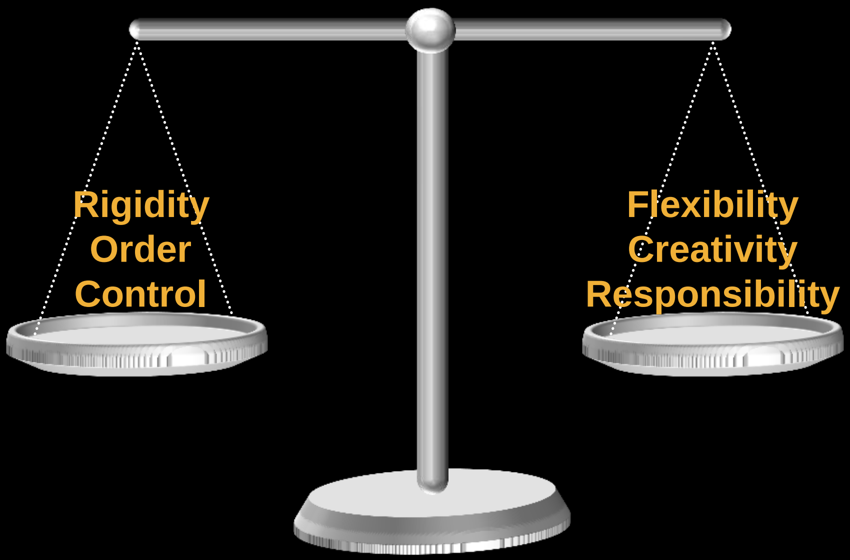
# Introduction

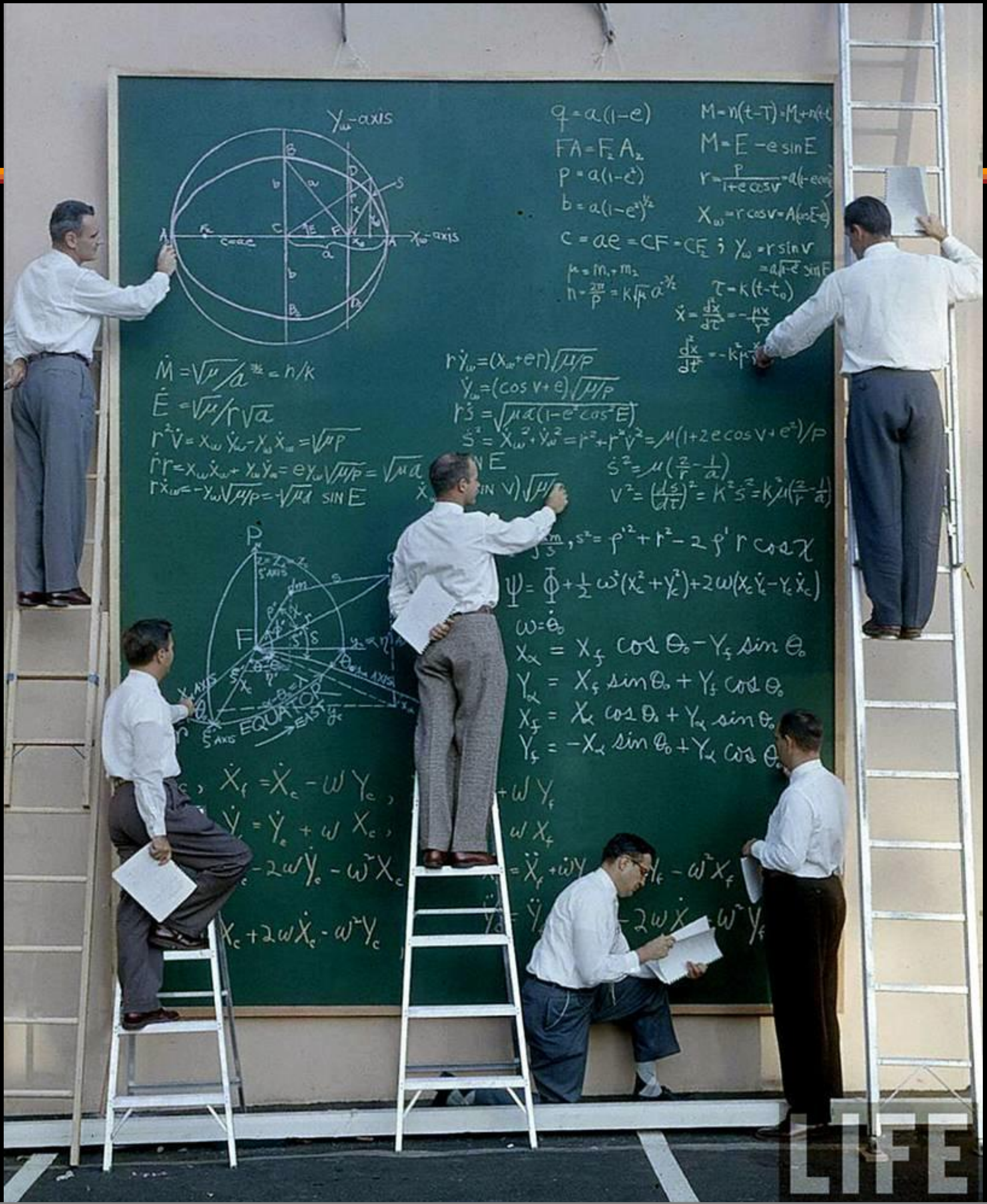
- Technology is evolving and changing the way we do business
- Staying on top of technology, developing new technology, and pushing its limits is essential to achieving our main objectives
  - NASA Missions
  - SLS: Safety, Affordability, and Sustainability
- NASA culture influences technology infusion
- How do we take advantage of and develop new technologies to become more efficient and build better products at a lower cost?
  - Bring technologies to a readiness level that is safe for operation on NASA systems
  - Maintain rigor in testing and acceptance to ensure quality
  - Transition new technology

# Introduction

- How can we enable programs/projects to traverse the lifecycle in a flexible, affordable and repeatable way?
  - Dealing with emerging technologies and methods
  - Encouraging culture change & understanding the workforce
  - Measuring design progress and success
  - Balancing rigidity with creativity
  - Responsive to broad portfolio of activities






**NASA Before PowerPoint**

**The physics are the same. How we communicate has changed.**

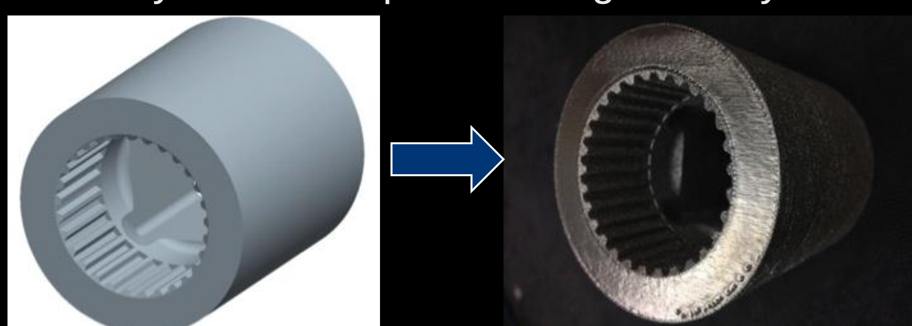
# Technologies Vary Depending on System

- The way we use new technology varies based on size, complexity, allowable risk, cost, schedule, etc.

- 3D models are now following the hardware from “Art to Part”

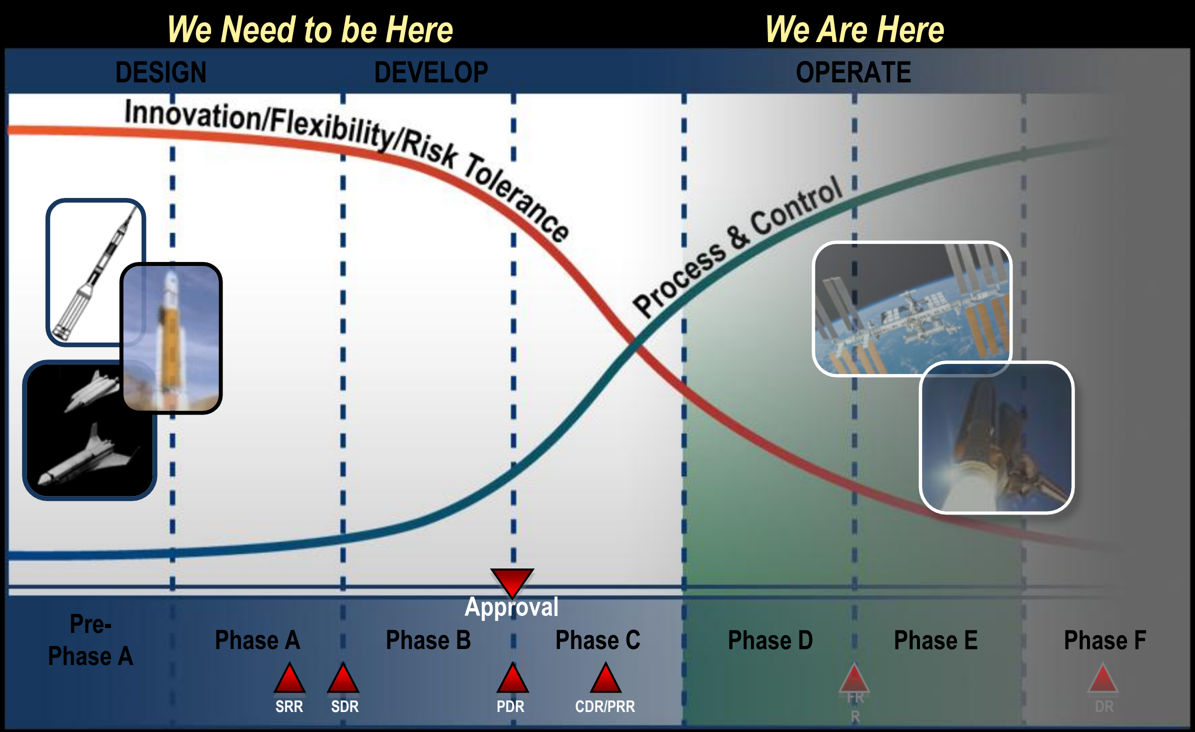
- Large Scale Hardware (Boost and Stage Engines, Stages, Vehicles)
  - More integrated design
  - We are better prepared for the hardware once we receive it
  - Better fabrication techniques

- Small Scale Hardware (components)
  - Prototypes
  - Analysis and test can be performed in parallel
  - Test multiple designs
  - Proceed beyond development at significantly lower risk



# Key Enabler is NASA Culture

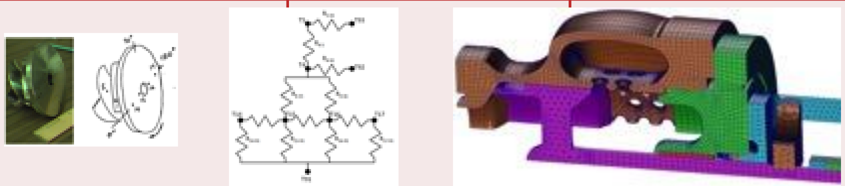
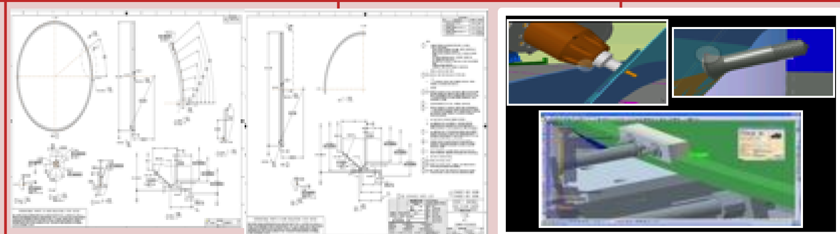
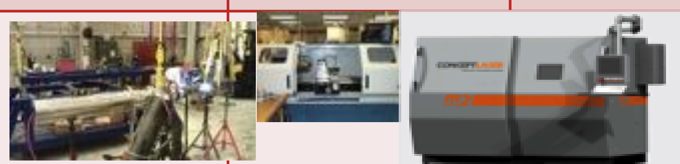
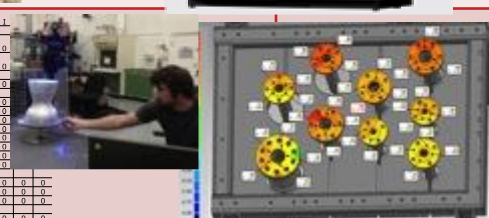
- Impact of new technology is enabled by a culture embracing innovation and flexibility that has a higher tolerance to risk
- Testing to *learn* versus testing to *pass*
- Getting past fears of the unknown




**One test is worth a thousand expert opinions – Wernher von Braun**

3D models are carried through all phases of the product life cycle.

More Automation

| | Past | Present | Future | What is changing? |
|---|---|---|---|---|
| Design |  | | | Design is becoming more integrated with manufacturing, shortening the product life cycle and reducing overall cost. Minimizes re-design, re-work. |
| Analysis |  | | | Computers are getting faster, memory is getting cheaper, leading to higher resolution analytical models. Analytical models are becoming more fully integrated. |
| Producibility, Modeling and Simulations |  | | | The transition from paper drawings to 3D design models and associated modeling and simulations have enabled advanced producibility analysis with great savings. We are also working towards using annotated models in place of drawings. |
| Manufacturing |  | | | Transitioning from manual processes to full automation, CNC milling, additive processes. |
| Inspection and Test | (see measurement table below)  | | | Transitioning from discrete measurements to structured light scanning, more full inspection coverage and the ability to compare “as built” directly to “as designed” models, reducing inspection time and increasing fidelity. |
| Logistics and Operations |  | | | Using 3D virtual simulations in addition to drawings to reduce cost and schedule by evaluating interfaces during the initial design phase. Simulations can significantly increase efficiency and preparedness for operations. |

| Labelçç | ActualX | ActualY | ActualZ | I | | |
|---|---|---|---|---|---|---|
| C_DEVICEPOS001 | | | | | | |
| M_PLANE001 | 0.3453 | -0.0139 | 0 | 0 | | |
| M_CIRCLE001_I | 0 | 0 | 0 | 0 | | |
| M_LINE001 | 5.6373 | 0.7553 | 0 | | | |
| C_COORDSYS001 | 0 | 0 | 0 | 0 | | |
| C_ALIGNMENT001 | | | | | | |
| M_POINT001 | 53.7429 | 37.9456 | 6.738 | 0 | | |
| M_POINT002 | 65.2972 | -6.3056 | 6.5745 | 0 | | |
| M_POINT003 | 61.493 | -11.345 | -18.992 | 0 | | |
| M_POINT004 | -53.105 | -38.714 | 6.5737 | 0 | | |
| M_POINT005 | -64.651 | 7.4137 | 6.4737 | 0 | | |
| M_POINT006 | 45.5545 | -7.5359 | 73.7245 | 0 | | |
| M_POINT007 | 48.788 | -9.274 | 94.8781 | 0 | | |
| M_POINT008 | 47.4436 | -15.478 | 120.66 | 0 | | |
| C_DEVICEPOS002 | | | | | | |
| M_POINT009 | -27.913 | 34.1752 | 73.1477 | 0 | 0 | 0 |
| M_POINT010 | -29.465 | 35.413 | 96.2339 | 0 | 0 | 0 |
| M_POINT011 | -32.774 | 37.0945 | 120.437 | 0 | 0 | 0 |
| C_DEVICEPOS003 | | | | | | |
| M_POINT012 | -30.539 | -32.851 | 73.3956 | 0 | 0 | 0 |
| M_POINT013 | -30.42 | -36.051 | 96.2743 | 0 | 0 | 0 |

## Typical Design Process

ATP → Requirements → Design Analysis → Manufacture → Test → Verify/Certify → Fly

## Evolved Design Process, Enabled by New Technologies

ATP → Requirements → Design / Integrated Analysis / Prototype Fabrication / Early verification of producibility / Early Prototype Testing → Verify/Certify → Fly

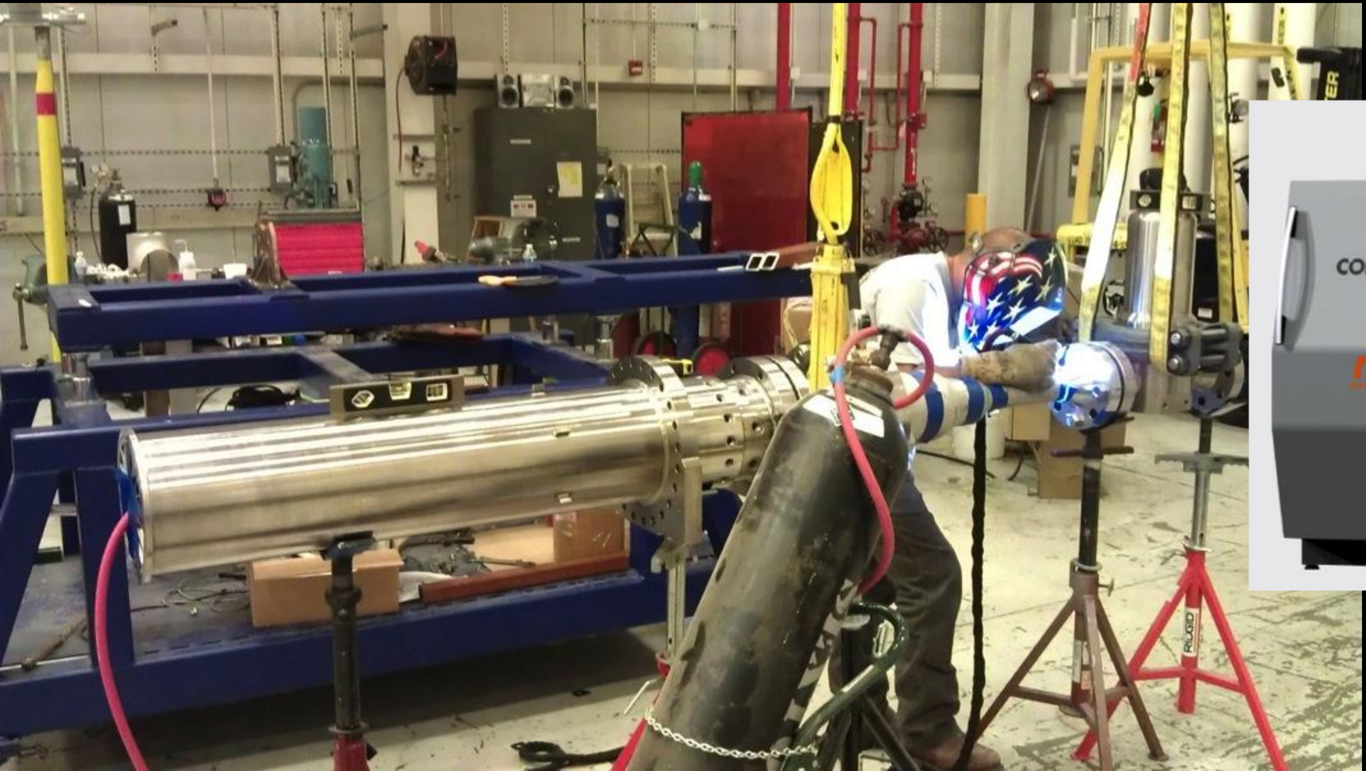
**Higher fidelity development**

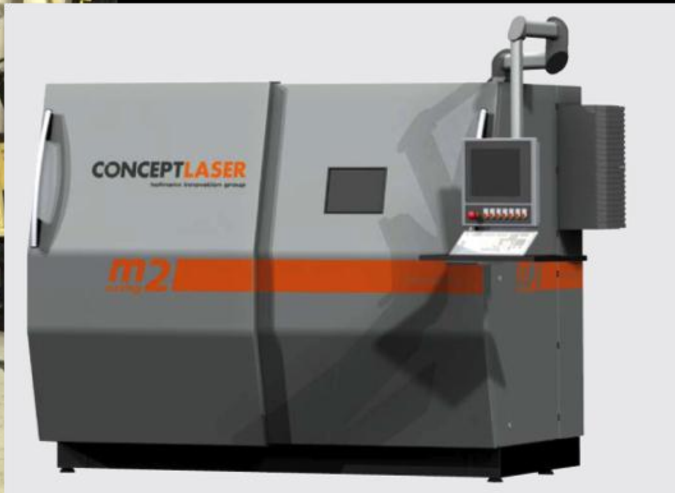
# Additive Manufacturing

- **What is Additive Manufacturing?**
  - Additive manufacturing  is used to build a part from the ground level up, typically starting with powder metal
    - Powder metal laser sintering (SLM), electron beam melting (EBM)
    - Laser deposition
    - “3D Printing” plastics, Stereolithography
      - Made in Space

# Additive Manufacturing

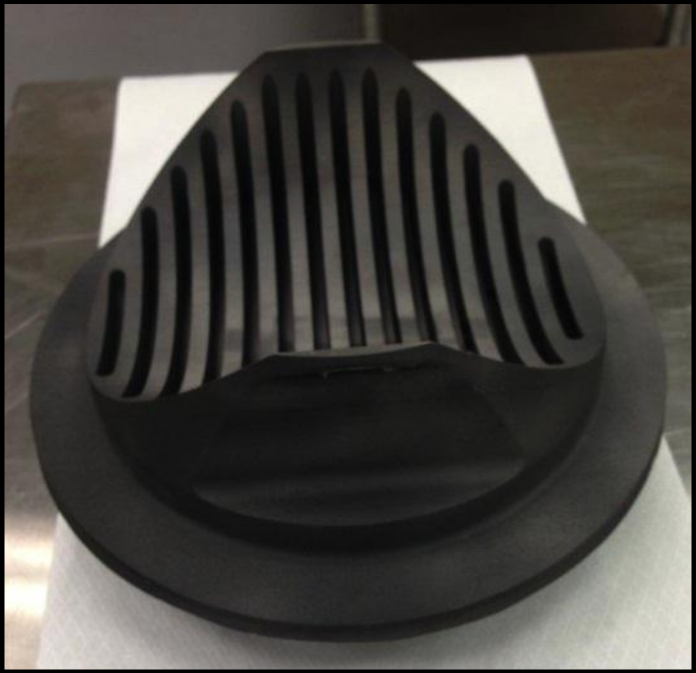
- **What is Additive Manufacturing?**
  - Differs from “traditional” machining
    - Subtractive machining: Cutting, milling, drilling
    - Joining: welding, brazing, fastening
    - Forming: melting, pouring castings
    - Significantly less “scrap”
  - In many cases, “traditional” methods are used in addition to additive





# Additive Manufacturing

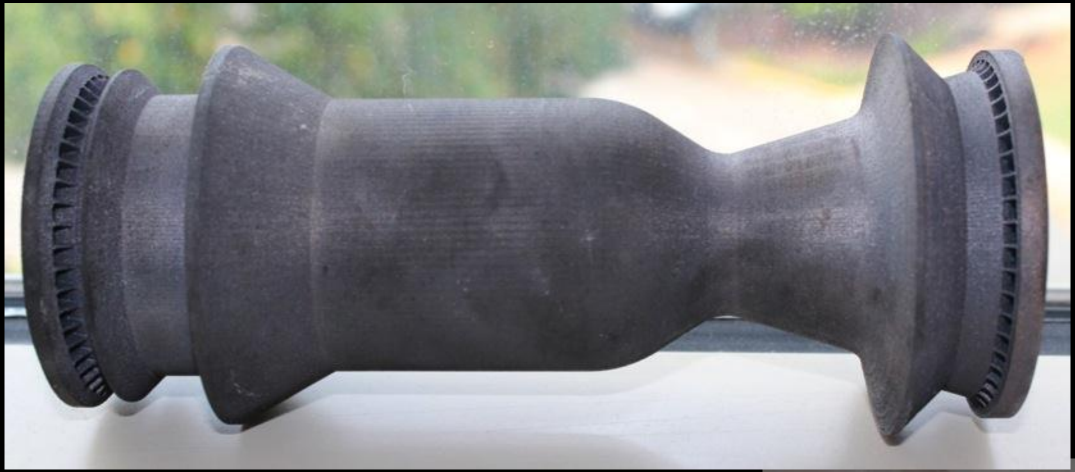
- **How do we fly SLM components?**
  - Build and test components
  - Mechanical testing on samples
  - In-process verification
  - Digital records
  - Quality control and Inspections
  - To qualify the process, let’s start with qualifying specific parts



- **Consider:**
  - Environment (fluid, pressure, temp)
  - Material
  - Criticality
  - Size
  - Function

# Additive Manufacturing

- Why Additive Manufacturing?
  - Key to Sustainable & Affordable Propulsion
  - Can significantly reduce cost and time to manufacture when applied effectively



**Examples:**

| Part | Cost Savings | Time Savings |
|---|---|---|
| J-2X Gas Generator Duct | 70% | 50% |
| F-1 Torque Adapter | N/A | 70% |
| Pogo Z-Baffle | 64% | 75% |
| Custom Wrenches | N/A | 70% |
| Turbopump Volute | 87% | 75% |
| Turbopump Inducer | 50% | 80% |

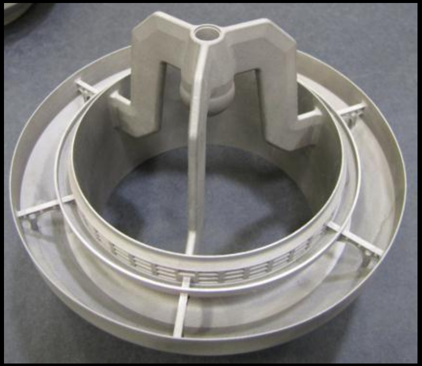

# Additive Manufacturing – Heritage Parts

- Additive Manufacturing can be used to fabricate heritage parts.
- Some small modifications may be required, but no change to "fit, form, or function."
- Goal: reduce part count, welds, machining operations → reduce $ and time

**J-2X Gas Generator Duct**

**Pogo Z-Baffle**

**RS-25 Flex Joint**



| Part | Cost Savings | Time Savings |
|---|---|---|
| J-2X Gas Generator Duct | 70% | 50% |
| Pogo Z-Baffle | 64% | 75% |

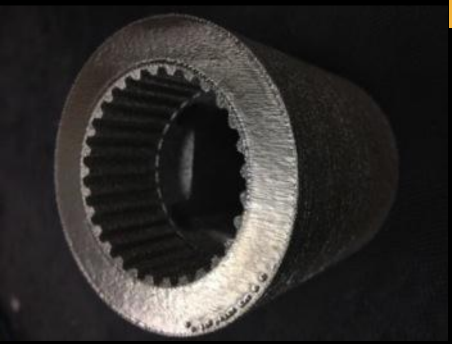
| RS-25 Flex Joint | Heritage Design | SLM Design |
|---|---|---|
| Part Count | 45 | 17 |
| # Welds | 70+ | 26 |
| Machining Operations | ~147 | ~57 |

# Additive Manufacturing – New Parts

- Fabricate new parts and tooling
- “Art to Part” in hours
- Design freedom and flexibility
- Design for function

| Part | Cost Savings | Time Savings |
|---|---|---|
| F-1 Torque Adapter | N/A | 70% |
| Custom Wrenches | N/A | 70% |
| Turbopump Inducer | 50% | 80% |

**Custom Tooling**




**Custom Instrumentation**

**Valve Housing**

**Turbopump Inducer**

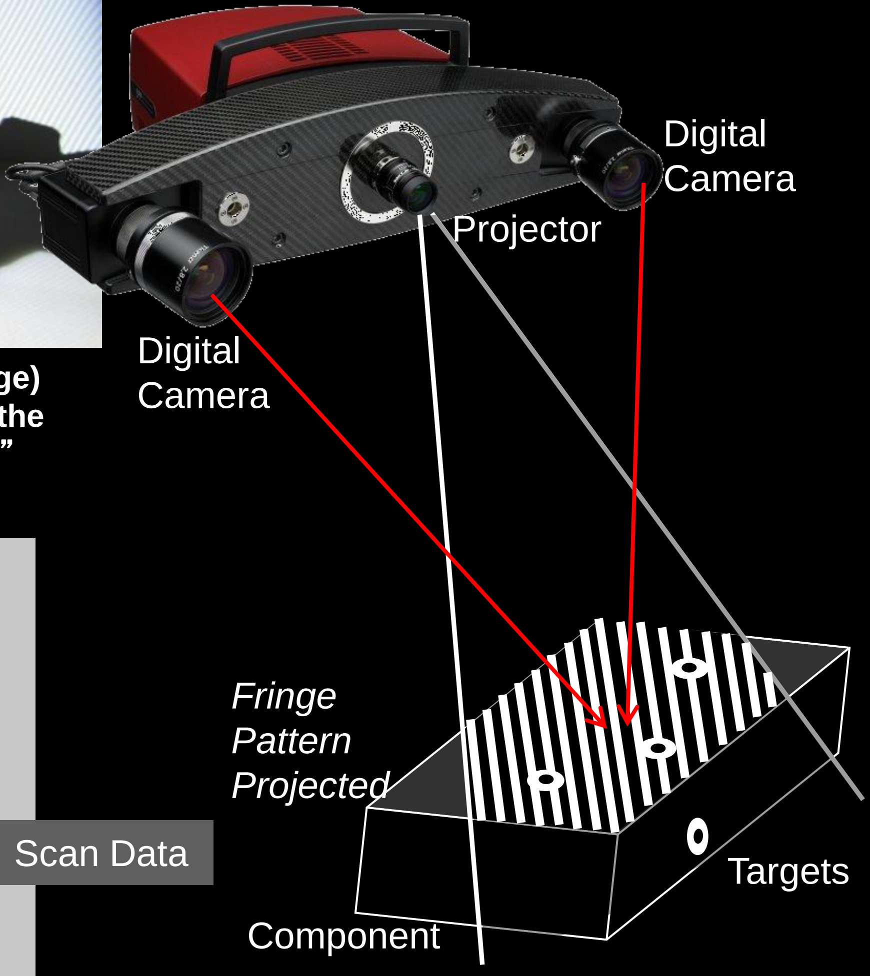
**Imagine the possibilities!**

# Structured Light Scanning

1. Targets are placed on the hardware

2. Structured light (fringe) pattern projected onto the component that “shifts” rapidly

3. Two digital cameras take a series of simultaneous images

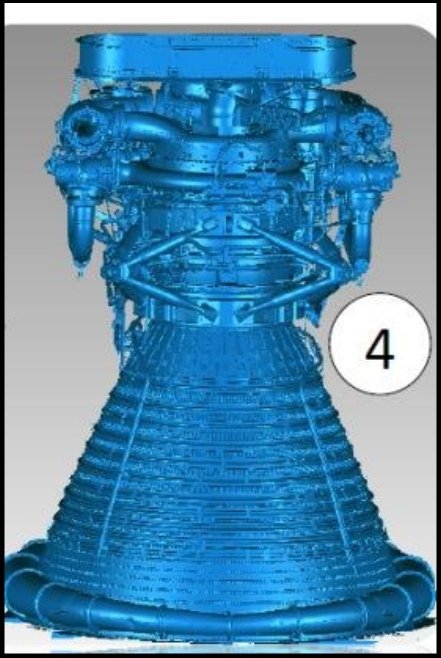




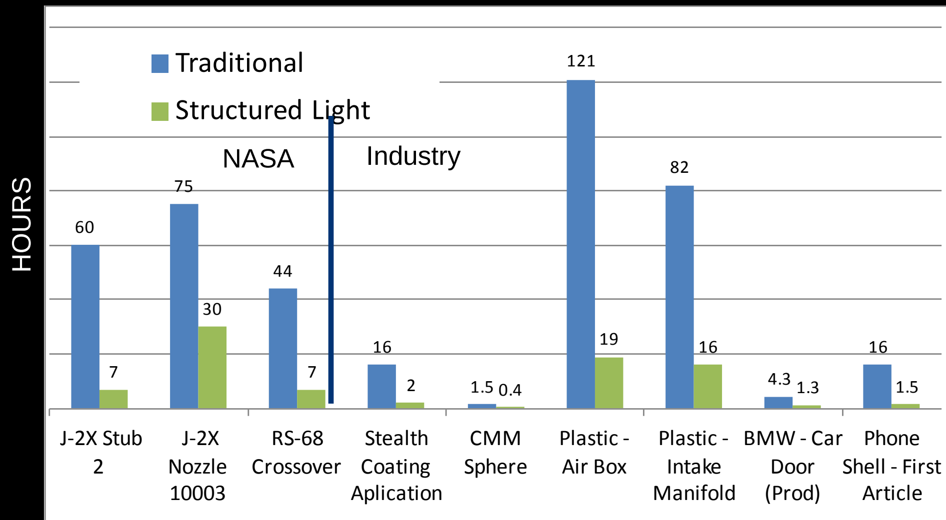

4. Series of simultaneous images and scans are processed in the software, and based on triangulation methods, the software will calculate 3D coordinates of the part and create a continuous contour

# Structured Light Scanning

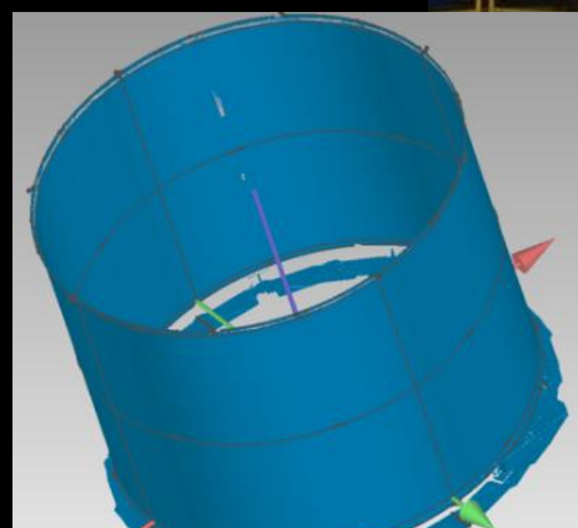
- Why do we scan?
  - Improve Process Development
  - Digital assembly reduces cost and schedule
  - Compare small changes in hardware not previously possible (test-to-test and before and after processes)
  - Refine Performance predictions
  - Reverse Engineering
  - Subtle details




# Structured Light Scanning




| X [in] | Y [in] | Z [in] |
|---|---|---|
| -109.9217 | -124.2430 | -43.3123 |
| -110.0193 | -124.1182 | -56.4270 |
| -105.7828 | -127.6776 | -70.2859 |
| -109.7748 | -124.1849 | -85.3763 |
| -91.6814 | -137.9978 | -90.5595 |
| -106.9735 | -126.5203 | -100.5115 |
| -93.5690 | -136.6574 | -114.7452 |
| -108.9994 | -126.7191 | -120.5574 |
| -142.9156 | -83.5798 | -46.7949 |
| -134.5051 | -96.9043 | -57.0983 |
| -121.9098 | -112.4051 | -69.7333 |
| -142.9033 | -83.6813 | -71.8773 |
| -130.4652 | -102.3074 | -72.6133 |
| -133.3204 | -98.5017 | -85.7894 |
| -124.6968 | -109.1472 | -99.6628 |
| -135.5319 | -95.2756 | -115.5736 |
| -122.3039 | -111.7613 | -116.7557 |
| -120.3983 | -120.3705 | -117.9078 |
| -135.9436 | -97.3176 | -120.5932 |
| -152.5696 | -63.2536 | -48.3422 |
| -150.0855 | -69.1317 | -57.4824 |
| -158.6293 | -47.0351 | -56.2611 |



**Better understanding of what we actually have**

# Program/Project Lifecycle

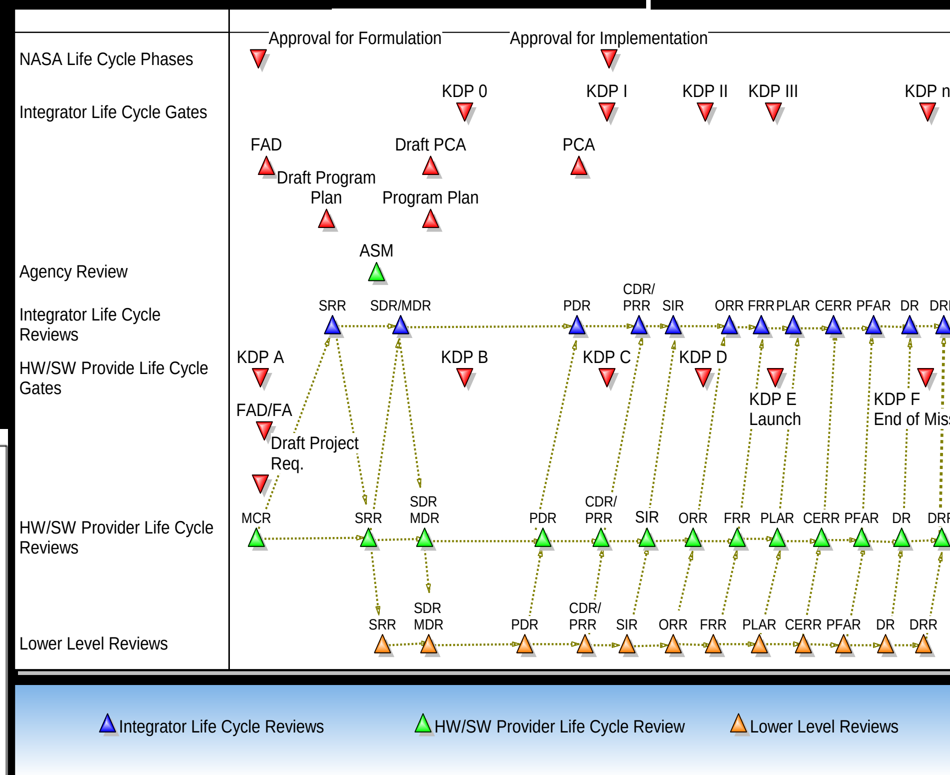
## The integrated lifecycle review expectations are unchanged

- Success criteria/milestones
- Products demonstrate progress
- Metrics & reviews measure success

| | | | |
|---|---|---|---|
| **Program SRR (P/SRR)** | **Entrance Criteria:**<br>B/L- Formulation Authorization Document (FAD) has been approved. (Reference Data)<br>D- Program Plan<br>P- Mission Directorate requirements and constraints<br>D- Traceability of program-level requirements on projects to the Agency strategic goals and Mission Directorate requirements and constraints<br>D- Documentation of driving ground rules and assumptions on the program<br>D- Interagency and international agreements<br>D- Documented Cost and Schedule Baselines<br>D- Documentation of Basis of Estimate (cost and schedule)<br>D- Shared Infrastructure,* Staffing, and Scarce Material Requirements and Plans<br>Plans for work to be accomplished during next Life Cycle Phase<br>D- Technical, Schedule, and Cost Control Plan<br>D- Safety and Mission Assurance (S&MA) Plan (STD/SA-SSP, STD/RM-RMP)<br>D- Risk Management Plan (STD/MA-RMP, STD/RM-PRAP)<br>D- Acquisition Plan<br>D- Technology Development Plan<br>D- Systems Engineering Management Plan (SEMP) (STD/SE-SEMP)<br>D- Information Technology (IT) Plan<br>P - Review plan<br>D- Configuration Management (CM) Plan (STD/CM-CMP, STD/SW-SCMP)<br>D- Lessons Learned Plan<br>D - Integration plan (*STD/SE-IP*)<br>Program requirements have been defined that support Mission Directorate requirements on the program.<br>Major program risks and corresponding mitigations strategies have been identified.<br>The high-level program requirements have been documented to include: a. performance, b. safety, and c. programmatic requirements, consistent with the selected Conceptual design from the project MCR.<br>An approach for verifying compliance with program requirements has been defined.<br>Procedures for controlling changes to program requirements have been defined and approved.<br>Traceability of program requirements to individual projects is documented in accordance with Agency needs, goals, and objectives, as described in the NASA Strategic Plan.<br>Top program/project risks with significant technical, safety, cost and schedule impacts have been identified. | **Exit Criteria:**<br>P- Program Plan<br>B/L- Mission Directorate requirements and constraints<br>P-Traceability of program-level requirements on projects to the Agency strategic goals and Mission Directorate requirements and constraints<br>P- Documentation of driving ground rules and assumptions<br>P- Interagency and international agreements<br>I - Risk mitigation plans and resources for significant risks<br>P- Documented Cost and Schedule Baselines<br>P- Documentation of Basis of Estimate BOE (cost and schedule)<br>I- Shared Infrastructure, Staffing, and Scarce Material Requirements and Plans<br>Plans for work to be accomplished during next Life Cycle Phase<br>P- Technical, Schedule, and Cost Control Plan<br>P- S&MA Plan (STD/SA-SSP, STD/RM-RMP)<br>P-Risk Management Plan (STD/MA-RMP, STD/RM-PRAP)<br>P-Acquisition Plan<br>P-Technology Development Plan<br>P- SEMP (STD/SE-SEMP)<br>P - IT Plan<br>B/L - Review Plan<br>P- CM Plan (STD/CM-CMP, STD/SW-SCMP)<br>P- Lessons Learned Plan<br>P- Integration plan (*STD/SE-IP*) | **Success Criteria:**<br>1. With respect to mission and science requirements, defined high-level program requirements are determined to be complete and are approved.<br>2. Defined interfaces with other programs are approved.<br>3. The program requirements are determined to provide a cost-effective program.<br>4. The program requirements are adequately levied on either the single-program project or the multiple projects of the program.<br>5. The plans for controlling program requirement changes have been approved.<br>6. The approach for verifying compliance with program requirements has been approved.<br>7. The mitigation strategies for handling identified major risks have been approved. |

SRR

Life Cycle Reviews

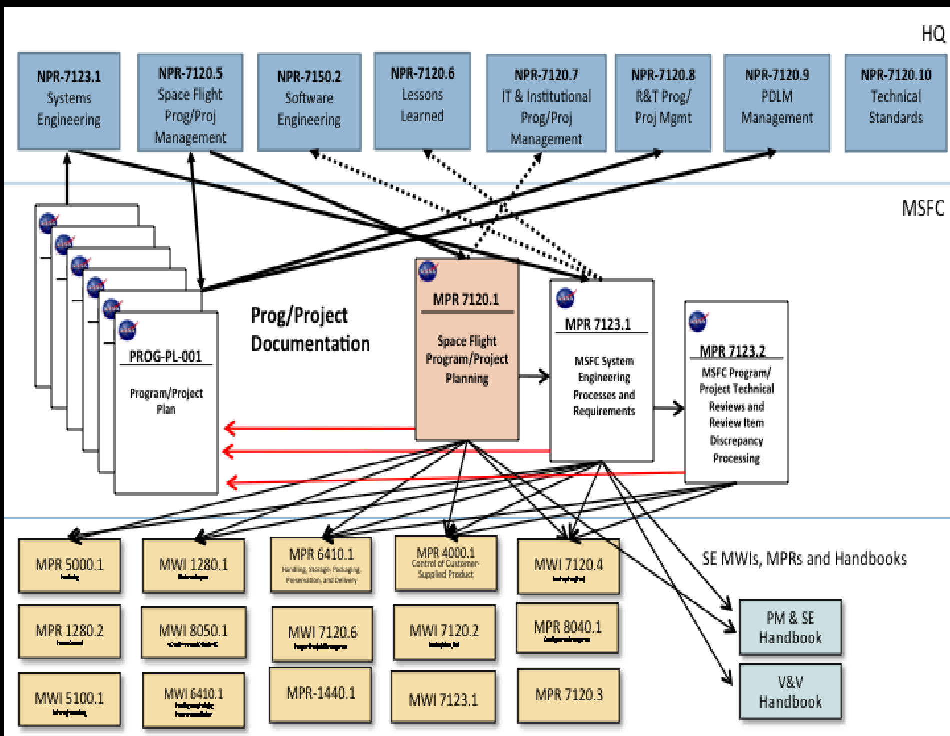


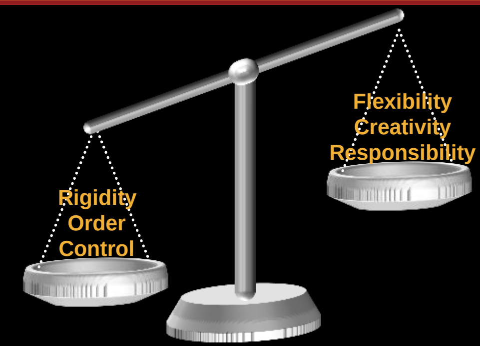

## What is changing

- Time & Resource Expectations
- Types of Programs/projects
- How we demonstrate success

# The Beginning

- Sea of policy, requirements and how-to
- One-sized
- Paper/document driven
- Rigid, blind compliance, minimize risk



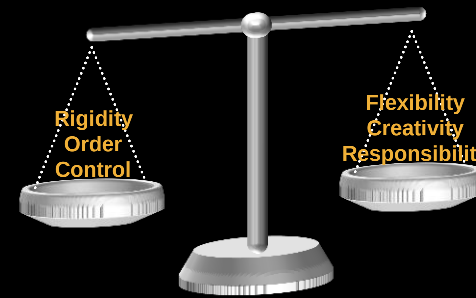



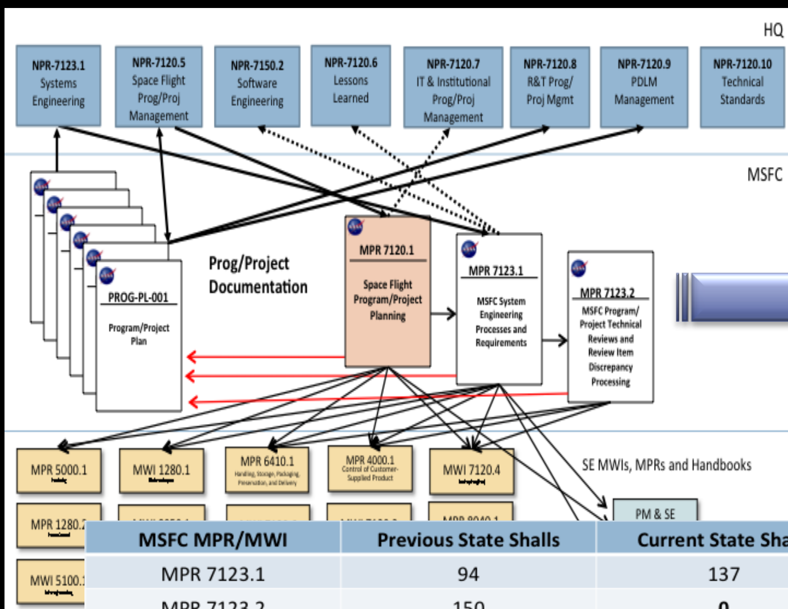


**Process Focus, do it as it is written!**

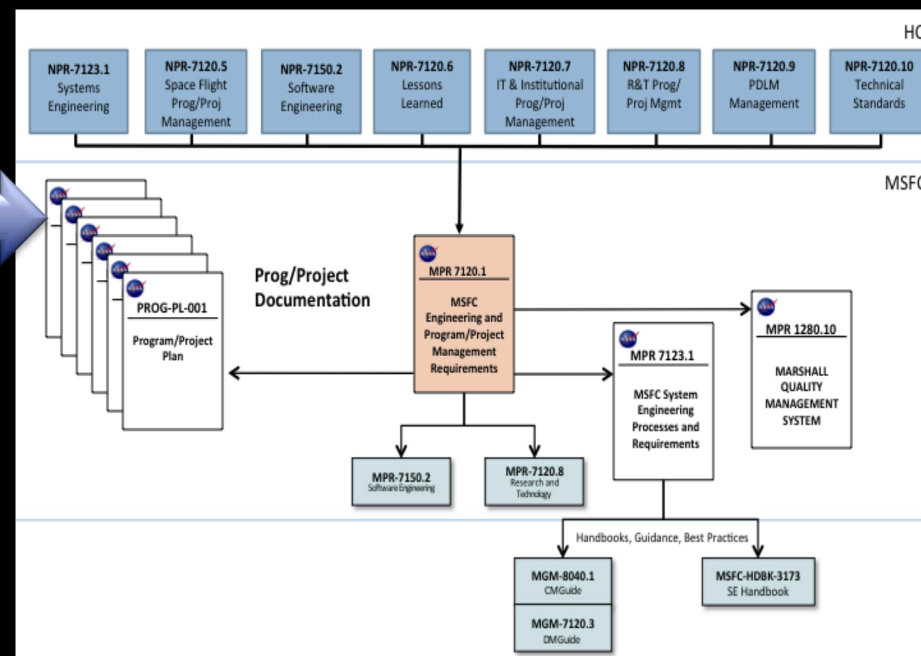
# Evolving how we do PM & SE

- Streamline – “One-Stop Shop”
- Promote thinking around circumstances
- Data Driven, document independent
- Flexible




| MSFC MPR/MWI | Previous State Shalls | Current State Shalls |
|---|---|---|
| MPR 7123.1 | 94 | 137 |
| MPR 7123.2 | 150 | 0 |
| MWI 7123.1 | 33 | 0 |
| MWI 8050.1 | 24 | 0 |
| MPR 8040.1 | 233 | 0 |
| MPR 7120.3 | 146 | 0 |
| MWI 7120.4 | 42 | 0 |
| MWI 7120.2 | 79 | 0 |
| MPR 7120.1 | 4 | 12 |
| Totals | 805 | 149 |
| Delta | -656 | |




Focus on the product, customize the process.

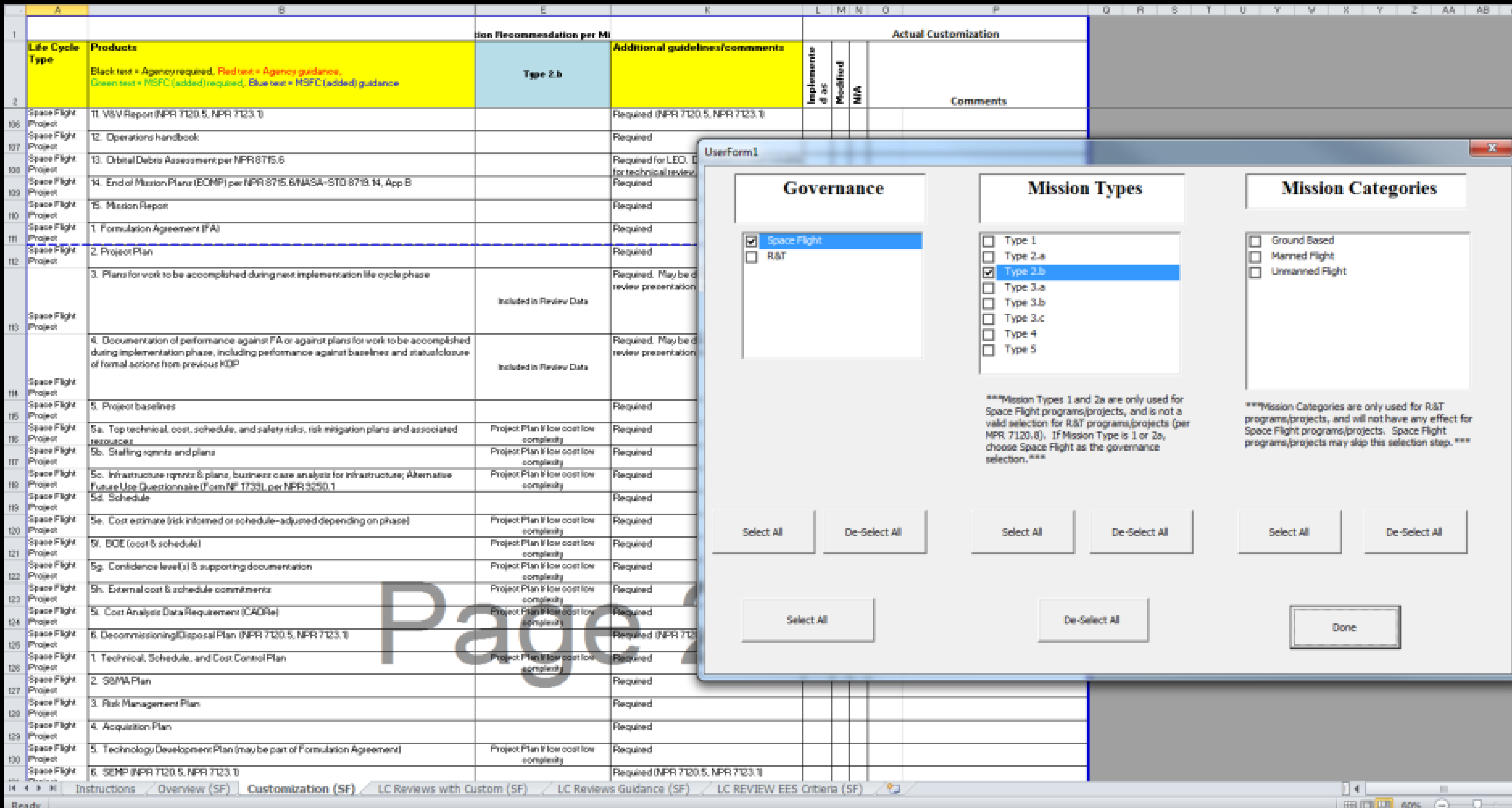
# Enablers: Find Your Project

- Projects stratified for MSFC portfolio (ranging from SLS to small activities)
- Find a starting place based on your Project type (size, priority, risk, cost…)

| | Type 1 | Type 2.a | Type 2.b | Type 3.a | Type 3.b | Type 3.c | Type 4 | Type 5 |
|---|---|---|---|---|---|---|---|---|
| **Guidance for Identifying Mission Types** | | | | | | | | |
| **Cost Guidance (estimate LCC)** | High(> ~$1B) | High to low (~$1B -$250M) | Low (~$250M - $100M) | (~$100M-$50M) | $50M-$10M | < $10M | > $1M/yr or > $10M LCC | < $1M/yr or < $10M LCC |
| **Priority (Criticality to Agency Strategic Plan)** | High to low priority | High to medium priority | High priority | Medium to low priority | Low Priority | Low to very low Priority | High (Center Priority) | Medium or Low (Center Priority) |
| **National Significance** | Very high | High | Medium | Medium | Low | Very Low | | |
| **Risk Tolerance** | Class A Risk: Very low (minimized) | Class B Risk: Low | Class C Risk: Medium | Class D Risk: High | Class D Risk: High | Class D Risk: High | | |
| **Description of the Types of Mission** | Human Space Flight or Very Large Science/Robotic Missions | Non-Human Space Flight or Science/Robotic Missions | Small Science (Human or Non human) | Smaller Science (Human or Non human) | Science (Human or non human) | Science (Human or non human) | Support to multiple directorates | Support to a single directorate |
| **Complexity** | Very high to high | High to Medium | Medium to Low | Low | Low | Low to Very Low | | |
| **Mission Lifetime (Primary Baseline Mission)** | Long. >5 years | Medium. 2-5 years | Short. <2 years | Short. <2 years | Short. <2 years | Short. <2 years | | |
| **Launch Constraints** | Critical | Medium | Few to none | Few to none | Few to none | None | | |
| **Achievement of Mission Success Criteria** | All practical measures are taken to achieve minimum risk to mission success. The highest assurance standards are used. | Stringent assurance standards with only minor compromises in application to maintain a low risk to mission success. | Medium or significant risk of not achieving mission success is permitted. Minimal assurance standards are permitted. | Significant risk of not achieving mission success is permitted. Minimal assurance standards are permitted. | Significant risk of not achieving mission success is permitted. Minimal assurance standards are permitted. | Significant risk of not achieving mission success is permitted. Minimal assurance standards are permitted. | | |
| **Examples** | HST, Chandra, Cassini, JIMO, JWST, MPCV, SLS, ISS | MER, MRO, Discovery payloads, ISS Facility Class payloads, Attached ISS payloads | ESSP, Explorer payloads, MIDES, ISS complex sub rack payloads, PA-1, ARES 1-X, MEDLI, CLARREO, SAGE III, Calipso, ISERV | SPARTAN, GAS Can, technology demonstrators, simple ISS, express middeck and sub rack payloads, SMEX, MISSE-X, EV-2 | IRVE-2, IRVE-3, HiFIRE, HyBoLT, ALHAT Earth Venture I, FASTSAT | DAWNAir, InFlame, Research, technology demonstrations, HEROES, ADDITIVE Manufacturing in Space, SWORDS Payloads, Nanosails | MSFC activities in support of : Request from program/projects outside of MSFC for MSFC supporting activities subject to Requesting organization's requirements. | MSFC activities in support of : Request from program/projects outside of MSFC for MSFC supporting activities subject to Requesting organization's requirements. |

# Enablers: Customize & Communicate

- Compare across the lifecycle, choose best fit
- Identify customization opportunities
- Communicate approach in a common way



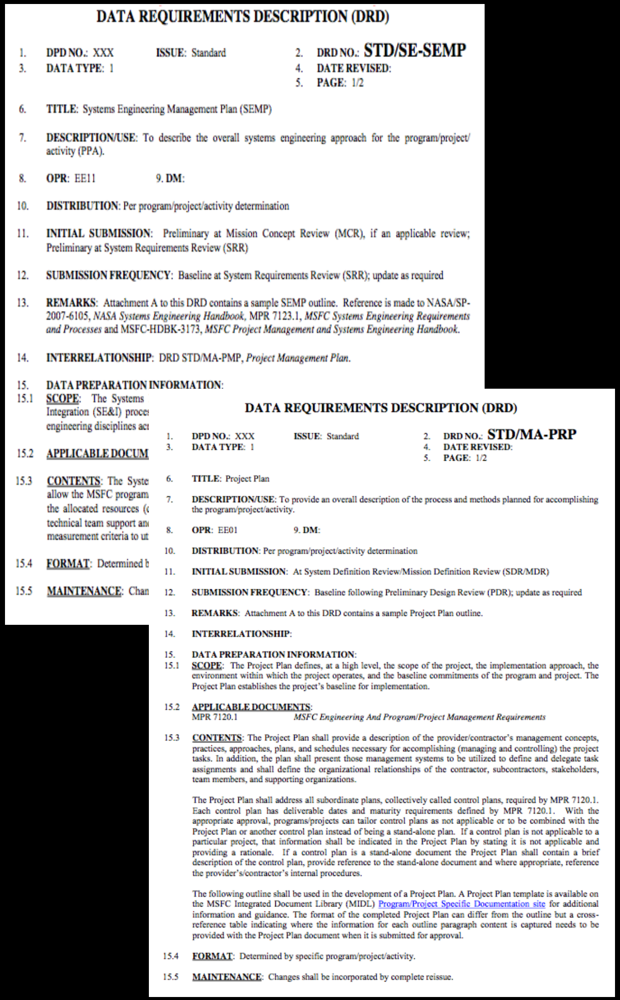
# Enablers: Reviews and Data

- Complete lifecycle perspective
- Approach products and design needs from a success perspective
- Understand requirements, best practices and data needs

| | | | |
|---|---|---|---|
| **Program SRR (P/SRR)** | **Entrance Criteria:**<br>B/L- Formulation Authorization Document (FAD) has been approved. (Reference Data)<br>D- Program Plan<br>P- Mission Directorate requirements and constraints<br>D- Traceability of program-level requirements on projects to the Agency strategic goals and Mission Directorate requirements and constraints<br>D- Documentation of driving ground rules and assumptions on the program<br>D- Interagency and international agreements<br>D- Documented Cost and Schedule Baselines<br>D- Documentation of Basis of Estimate (cost and schedule)<br>D- Shared Infrastructure,* Staffing, and Scarce Material Requirements and Plans<br>Plans for work to be accomplished during next Life Cycle Phase<br>D- Technical, Schedule, and Cost Control Plan<br>D- Safety and Mission Assurance (S&MA) Plan (STD/SA-SSP, STD/RM-RMP)<br>D- Risk Management Plan (STD/MA-RMP, STD/RM-PRAP)<br>D- Acquisition Plan<br>D- Technology Development Plan<br>D- Systems Engineering Management Plan (SEMP) (STD/SE-SEMP)<br>D- Information Technology (IT) Plan<br>P - Review plan<br>D- Configuration Management (CM) Plan (STD/CM-CMP, STD/SW-SCMP)<br>D- Lessons Learned Plan<br>D - Integration plan (*STD/SE-IP*)<br>Program requirements have been defined that support mission directorate requirements on the program.<br>Major program risks and corresponding mitigations strategies have been identified.<br>The high-level program requirements have been documented to include: a. performance, b. safety, and c. programmatic requirements, consistent with the selected Conceptual design from the project MCR.<br>An approach for verifying compliance with program requirements has been defined.<br>Procedures for controlling changes to program requirements have been defined and approved.<br>Traceability of program requirements to individual projects is documented in accordance with Agency needs, goals, and objectives, as described in the NASA Strategic Plan.<br>Top program/project risks with significant technical, safety, cost and schedule impacts have been identified. | **Exit Criteria:**<br>P- Program Plan<br>B/L- Mission Directorate requirements and constraints<br>P-Traceability of program-level requirements on projects to the Agency strategic goals and Mission Directorate requirements and constraints<br>P- Documentation of driving ground rules and assumptions<br>P- Interagency and international agreements<br>I - Risk mitigation plans and resources for significant risks<br>P- Documented Cost and Schedule Baselines<br>P- Documentation of Basis of Estimate BOE (cost and schedule)<br>I- Shared Infrastructure, Staffing, and Scarce Material Requirements and Plans<br>Plans for work to be accomplished during next Life Cycle Phase<br>P- Technical, Schedule, and Cost Control Plan<br>P- S&MA Plan (STD/SA-SSP, STD/RM-RMP)<br>P-Risk Management Plan (STD/MA-RMP, STD/RM-PRAP)<br>P-Acquisition Plan<br>P-Technology Development Plan<br>P- SEMP (STD/SE-SEMP)<br>P - IT Plan<br>B/L - Review Plan<br>P- CM Plan (STD/CM-CMP, STD/SW-SCMP)<br>P- Lessons Learned Plan<br>P- Integration plan (*STD/SE-IP*) | **Success Criteria:**<br>1. With respect to mission and science requirements, defined high-level program requirements are determined to be complete and are approved.<br>2. Defined interfaces with other programs are approved.<br>3. The program requirements are determined to provide a cost-effective program.<br>4. The program requirements are adequately levied on either the single-program project or the multiple projects of the program.<br>5. The plans for controlling program requirement changes have been approved.<br>6. The approach for verifying compliance with program requirements has been approved.<br>7. The mitigation strategies for handling identified major risks have been approved. |

# Enablers:  Support

- Flexible Data Requirements templates
- Guidance & Best Practices
- Lessons Learned and Knowledge Management



**DATA REQUIREMENTS DESCRIPTION (DRD)**

1. DPD NO.: XXX  ISSUE: Standard
2. DRD NO.: STD/SE-SEMP
3. DATA TYPE: 1
4. DATE REVISED:
5. PAGE: 1/2

6. **TITLE**: Systems Engineering Management Plan (SEMP)

7. **DESCRIPTION/USE**: To describe the overall systems engineering approach for the program/project/activity (PPA).

8. **OPR**: EE11  9. **DM**:

10. **DISTRIBUTION**: Per program/project/activity determination

11. **INITIAL SUBMISSION**: Preliminary at Mission Concept Review (MCR), if an applicable review; Preliminary at System Requirements Review (SRR)

12. **SUBMISSION FREQUENCY**: Baseline at System Requirements Review (SRR); update as required

13. **REMARKS**: Attachment A to this DRD contains a sample SEMP outline. Reference is made to NASA/SP-2007-6105, *NASA Systems Engineering Handbook*, MPR 7123.1, *MSFC Systems Engineering Requirements and Processes* and MSFC-HDBK-3173, *MSFC Project Management and Systems Engineering Handbook*.

14. **INTERRELATIONSHIP**: DRD STD/MA-PMP, *Project Management Plan*.

15. **DATA PREPARATION INFORMATION**:

15.1 SCOPE: The Systems Integration (SE&I) proce engineering disciplines ac

15.2 APPLICABLE DOCUM

15.3 CONTENTS: The Syste allow the MSFC program the allocated resources ( technical team support an measurement criteria to u

15.4 FORMAT: Determined b

15.5 MAINTENANCE: Chan

**DATA REQUIREMENTS DESCRIPTION (DRD)**

1. DPD NO.: XXX  ISSUE: Standard
2. DRD NO.: STD/MA-PRP
3. DATA TYPE: 1
4. DATE REVISED:
5. PAGE: 1/2

6. **TITLE**: Project Plan

7. **DESCRIPTION/USE**: To provide an overall description of the process and methods planned for accomplishing the program/project/activity.

8. **OPR**: EE01  9. **DM**:

10. **DISTRIBUTION**: Per program/project/activity determination

11. **INITIAL SUBMISSION**: At System Definition Review/Mission Definition Review (SDR/MDR)

12. **SUBMISSION FREQUENCY**: Baseline following Preliminary Design Review (PDR); update as required

13. **REMARKS**: Attachment A to this DRD contains a sample Project Plan outline.

14. **INTERRELATIONSHIP**:

15. **DATA PREPARATION INFORMATION**:

15.1 SCOPE: The Project Plan defines, at a high level, the scope of the project, the implementation approach, the environment within which the project operates, and the baseline commitments of the program and project. The Project Plan establishes the project's baseline for implementation.

15.2 APPLICABLE DOCUMENTS:
MPR 7120.1 *MSFC Engineering And Program/Project Management Requirements*

15.3 CONTENTS: The Project Plan shall provide a description of the provider/contractor's management concepts, practices, approaches, plans, and schedules necessary for accomplishing (managing and controlling) the project tasks. In addition, the plan shall present those management systems to be utilized to define and delegate task assignments and shall define the organizational relationships of the contractor, subcontractors, stakeholders, team members, and supporting organizations.

The Project Plan shall address all subordinate plans, collectively called control plans, required by MPR 7120.1. Each control plan has deliverable dates and maturity requirements defined by MPR 7120.1. With the appropriate approval, programs/projects can tailor control plans as not applicable or to be combined with the Project Plan or another control plan instead of being a stand-alone plan. If a control plan is not applicable to a particular project, that information shall be indicated in the Project Plan by stating it is not applicable and providing a rationale. If a control plan is a stand-alone document the Project Plan shall contain a brief description of the control plan, provide reference to the stand-alone document and where appropriate, reference the provider's/contractor's internal procedures.

The following outline shall be used in the development of a Project Plan. A Project Plan template is available on the MSFC Integrated Document Library (MIDL) Program/Project Specific Documentation site for additional information and guidance. The format of the completed Project Plan can differ from the outline but a cross-reference table indicating where the information for each outline paragraph content is captured needs to be provided with the Project Plan document when it is submitted for approval.

15.4 FORMAT: Determined by specific program/project/activity.

15.5 MAINTENANCE: Changes shall be incorporated by complete reissue.

National Aeronautics and Space Administration

MSFC-HDBK-3173
Revision B
EFFECTIVE DATE: October 16, 2012

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

EE11
MSFC TECHNICAL STANDARD

PROJECT MANAGEMENT AND SYSTEMS ENGINEERING HANDBOOK

Approved for Public Release; Distribution is Unlimited

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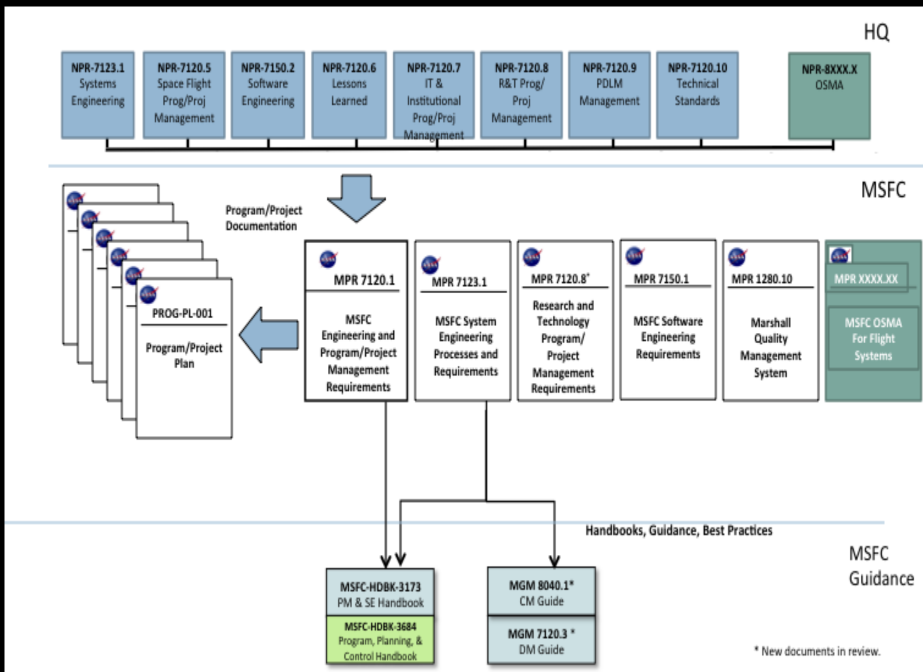
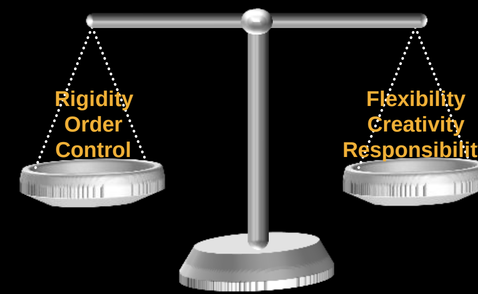
# Future State

- Integrate & Streamline S&MA Policy

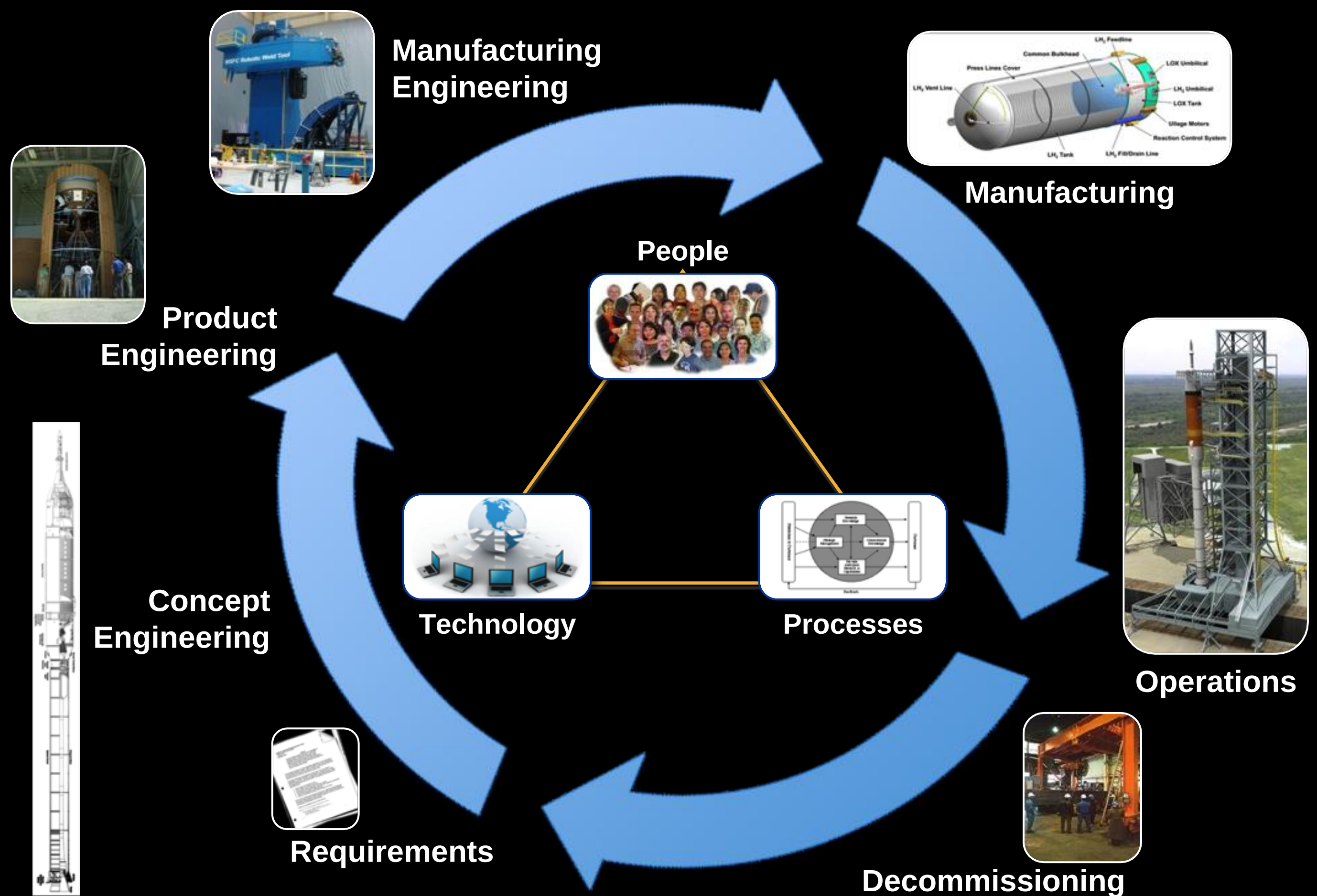



- PM & SE Process Model

# Future State

- Product Data Lifecycle Management, Model Based Engineering & Systems Engineering
- Capturing & communicating design best practices
- SE & PM development (culture, skills, training)

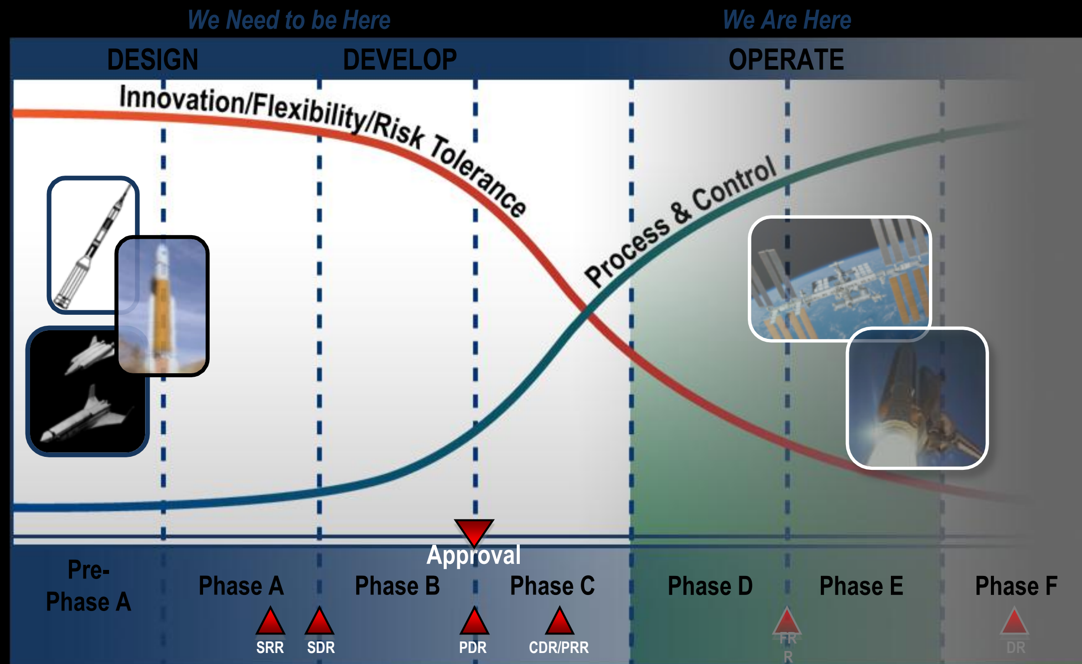


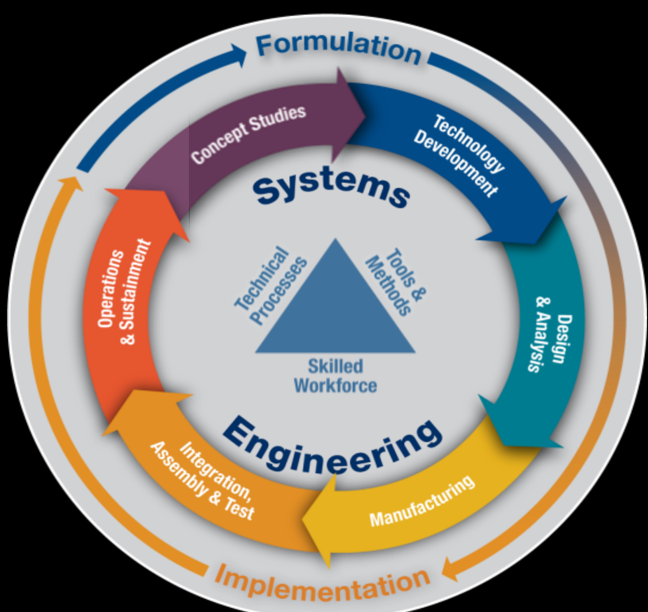

Every project is an opportunity to learn!

# Summary

Technology is changing the way we do design, analysis, logistics and operations

- Evolved capabilities
- Focus on integration earlier
- Parallel development and fabrication
- Enabled by a culture that embraces innovation and flexibility




Focus on balancing process rigidity with flexibility

- Promote thinking, not blind compliance
- Adjust to program/project size
- Integration & communication
- Product not process

# Question & Answer Session

**www.nasa.gov/marshall**